Magnetic Properties of Platinum Metal Alloys

PAPERS AT THE INTERNATIONAL CONFERENCE

A number of the papers presented at the International Conference on Magnetism held at the University of Nottingham in September dealt with alloys of the platinum metals. The proceedings will be published shortly by the Institute of Physics and the Physical Society.

Papers describing neutron diffraction studies demonstrated the powerfulness of some of the recently developed techniques. Thus G. G. Low of AERE, Harwell, described how the detailed distribution of magnetisation in dilute solutions of iron in palladium can be studied. In an alloy containing only 0.25 atomic per cent iron the magnetic structure at liquid helium temperatures shows a magnetisation of palladium atoms extending many interatomic distances from an iron atom. At about 4 per cent iron the "spheres of influence" overlap and the alloy consists of iron moments in an almost uniformly magnetised palladium matrix. Other workers have studied ordered alloys, examining the magnitude and symmetry of the spin distribution about the different types of atom.

Shirane, Nathans, Pickart and Alperin find moments of 3.1 Bohr magnetons (μ_B) for Fe and 1.0 μ_B for Rh in FeRh, the spin distribution being spherically symmetric around iron atoms but with a preference for the [001] direction around rhodium atoms. In Pd_3Fe both distributions were approximately spherical and corresponded to 0.34 μ_B for Pd and 2.86 μ_B for Fe. A group from the Centre for Nuclear Studies in Rome described similar work on $CoPt_3$ ($\mu_{Pt}=0.23 \pm .04$ μ_B, $\mu_{Co}=1.56 \pm .08$ μ_B) where indications of a non-spherical spin distribution around cobalt atoms were found, and on FePd which showed approximately spherical distributions.

Detailed information about atomic magnetism can also be provided by magnetic resonance studies. V. Jaccarino of the Bell Laboratory surveyed nuclear magnetic resonance and presented results for the temperature dependence of the shift (Knight shift) in this resonance from that in non-metallic environments for pure palladium; the Knight shift shows a temperature dependence very like that of the susceptibility, and is evidence against the existence of low temperature antiferromagnetism. In platinum the Knight shift is negative, but the change in its magnitude on alloying shows that it is associated with the susceptibility of the d-electrons. Froidevaux, Gautier and Weisman gave results for PtAu alloys, and a group from the Tata Institute in Bombay for intermetallic compounds of platinum with tin, lead and mercury.

More conventional magnetic properties of more direct practical importance were described for platinum-cobalt alloys. McCurrie and Gaunt (University of Sheffield) studied magnetisation as a function of order in the 50 atomic per cent alloy where a well-known cubic to tetragonal transformation takes place, and discussed the locking of domain walls by tetragonal lamellae. Clark and Phillips (University of Nottingham) examined the behaviour of 50 atomic per cent platinum alloys in which chromium was substituted for up to four-fifths of the cobalt. In a 40 per cent Co, 10 per cent Cr alloy the largest BH_{max} (2×10^6 gauss oersted) after annealing at 650°C was associated with an intermediate stage in the ordering; domain patterns were also studied.

Associated electrical resistivity and magnetic susceptibility behaviour were described for some platinum metal alloys. Coles, Loram and Waszink (Imperial College) described the low temperature behaviour of dilute solutions of iron in palladium and rhodium; in the latter no magnetic ordering is found up to 1 per cent Fe but low temperature resistance anomalies occur. Bates and Unstead (University of Nottingham) presented data for palladium-thorium alloys where reductions of the susceptibility of palladium by alloying are related to those occurring in palladium-uranium and other alloys.

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Quality Control in the Iron Foundry

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Control of metal quality is becoming increasingly important in the ironfounding industry as customers demand tighter specifications and apply more rigorous inspection techniques on the components ordered.

The three basic constituents of cast iron that affect strength, hardness and chilling characteristics are total carbon, silicon and phosphorus. The index which combines the effects of these elements is known as the carbon equivalent value and is normally calculated from the simple formula:

$$\text{Total carbon } \% + \frac{\text{Silicon } \% + \text{Phosphorus } \%}{3}$$

To meet specification requirements there is an obvious need to know the chemical analysis, carbon equivalent value or chilling characteristics of the metal as soon as it has been tapped from the furnace and before it is poured into the moulds. Chemical analysis is too slow, spectrographic analysis gives only the silicon value unless special techniques—too expensive for the majority of foundries—are used, and the chill test is open to a number of operational variables.

The technique for the determination of the carbon equivalent value from the cooling curve of a sample of iron has already been described in this journal (*Platinum Metals Review*, 1962, **6**, 20). The apparatus employed consists of a platinum : 13 per cent rhodium-platinum thermocouple, sheathed in silica and placed centrally in a mould cavity approximately $2\frac{1}{4}$ inches diameter by 3 inches high. The thermocouple is connected to an automatic temperature recorder and when the sample of metal is poured into the mould, the liquidus arrest temperature can be read off a chart.

Using this technique it is possible to determine the carbon equivalent value within about one minute of casting the sample and the value obtained is usually within ±0.05 of that obtained from calculating the value from analysis results—an error within the limits of analytical reproducibility. The quality of the metal can, therefore, be assessed before the castings are poured and, if necessary, corrections can be made. The technique has now found wide application in the ironfounding industry and in this country alone it is in use in at least seventy foundries.

Determining carbon equivalent value in the iron foundry

It is also important to control the pouring temperature, and a suitably adapted two-stage recorder with two platinum : rhodium-platinum couples is now available to measure both carbon equivalent value and the temperature of the molten metal.

The value of this "shop-floor" metal control method has been realised by the foundry staff and the cost of the equipment has been quickly recovered from the decrease in the number of defective castings produced.